

What is claimed is:

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1. A method of stabilizing the polarization of a vertical cavity surface emitting laser (VCSEL) device, comprising:

providing two or more VCSEL elements capable of emitting substantially a single mode radiation of substantially the same wavelength and arranged to allow phase-coupling between the two or more VCSEL elements, and

initiating emission of radiation by injecting current into the two or more VCSEL elements to produce phase-coupled radiation, wherein the polarization direction of each of the two or more VCSEL elements remains substantially constant during operation.
 2. The method of claim 1 further comprising:

providing a phase-coupling region between adjacent VCSEL elements, the phase-coupling region having a lateral dimension and a longitudinal dimension, substantially perpendicular to the major emission direction of the VCSEL device, the lateral dimension being less than the longitudinal dimension, wherein the lateral dimension is in the range from about 7 μm to about 0.1 μm .
 3. The method of claim 1, wherein in each VCSEL element, a radiation window is provided with a size from about 40 μm^2 to about 1 μm^2 .
 4. The method of claim 1, wherein a reflectivity difference between a resonator region corresponding to a radiation window of each of the VCSEL elements and a phase-coupling region provided between adjacent VCSEL elements is selected to be within about 0.5% to 15%.
 5. The method of claim 1, wherein two to five VCSEL elements are provided.

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Sub A37 6. The method of claim 1, wherein said two or more VCSEL elements are top-emitting VCSEL elements.

7. The method of claim 4, further comprising:

providing the phase-coupling region, at least partially, as an electrically conductive material.

8. The method of claim 7, wherein the phase-coupling region is provided on top of a distributed Bragg reflector to define radiation windows corresponding to each VCSEL element.

9. The method of claim 7, wherein the phase-coupling region is used as an injection electrode for injecting current.

10. The method of claim 7, wherein the phase-coupling region is provided as a grid layer vertically arranged between a first mirror means and a second mirror means.

11. The method of claim 7, further comprising:

providing a second phase-coupling region dividing each of the VCSEL elements into two or more sub portions, the second phase-coupling region generating a second reflectivity difference between resonator regions covered by the second phase-coupling region and resonator regions not covered by the second phase-coupling region, wherein the second reflectivity difference differs from the reflectivity difference created by the phase-coupling region.

Sub A47 12. The method of claim 1, wherein said two or more VCSEL elements are arranged as an array defined by a phase-coupling region formed on top of a top Bragg reflector of the VCSEL device.

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13. The method of claim 12, wherein the phase-coupling region is provided as a grid layer, that is at least partially conductive, and is used to inhomogeneously inject current.
14. The method of claim 13, wherein stripes of said grid layer extending along a first direction and stripes extending along a second direction are supplied with different currents respectively.
15. The method of claim 14, wherein a radiation emitting surface of each of the VCSEL elements is substantially of square shape, rectangular shape, diamond shape, or hexagonal shape.
16. The method of claim 12, wherein the array is asymmetric.
17. The method of any of claims 1 to 16, further comprising:

providing a polarization adjusting means to select a pre-defined polarization direction.
18. The method of claim 17, further comprising:

providing a strain element in the polarization adjusting means to produce orientation-dependent strain in one or more of the VCSEL elements.
19. The method of claim 18, further comprising:

providing a means for selecting a pre-defined orientation of said orientation-dependent strain.
20. The method of claim 1, wherein the VCSEL elements are operated in a continuous wave mode.

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21. A polarization-stable VCSEL device comprising:
- an arrangement of two to five phase-coupled VCSEL elements, wherein, during operation, the polarization direction of each of the VCSEL elements remains substantially constant.
22. A polarization-stable VCSEL device comprising:
- a plurality of phase-coupled VCSEL elements; and
- a polarization adjusting means provided in one or more of the phase-coupled VCSEL elements to select a pre-defined polarization direction.
23. The polarization-stable VCSEL device of claim 22, wherein the polarization adjusting means comprises a strain element to produce an orientation-dependent strain in one or more of the phase-coupled VCSEL elements.
24. The polarization-stable VCSEL device of claim 23, wherein said strain element comprises a strain layer including one or more shrunk material layers to create said orientation-dependent strain.
25. The polarization-stable VCSEL device of claim 22, wherein the polarization adjusting means comprises electrodes adapted to allow inhomogeneous injection of current into the VCSEL elements.
26. The polarization-stable VCSEL device of claim 25, wherein said electrodes are arranged in accordance with a crystallographic orientation of a substrate on which the VCSEL device is formed.
27. The polarization-stable VCSEL device of claim 26, wherein electrodes oriented in a first crystallographic direction are electrically insulated from electrodes oriented in a second crystallographic direction.

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28. The polarization-stable VCSEL device of claim 22, wherein the plurality of phase-coupled VCSEL elements are arranged in an array defined by a grid layer comprising electrically conductive portions.
29. The polarization-stable VCSEL device of claim 28, wherein first stripes of the grid layer extend along a first direction and second stripes extend along a second direction whereby a width of the first stripes is less than a width of the second stripes.
30. The polarization-stable VCSEL device of claim 28 or 29, wherein said array is asymmetric.
31. The polarization-stable VCSEL device of claim 28, wherein each element of the array is of square shape.
32. The polarization-stable VCSEL device of claim 28, wherein each element of the array is of rectangular shape.
33. The polarization-stable VCSEL device of claim 22, wherein respective emission windows of said plurality of VCSEL elements are of polygonal shape.
34. The polarization-stable VCSEL device of claim 21, further comprising:

a phase-matching layer on top of a distributed Bragg reflector, the phase-matching layer adjusting a reflectivity difference of the VCSEL resonator area below a radiation window and below a region separating two adjacent VCSEL elements to about 0.5 to about 3%.
35. The polarization-stable VCSEL device of claim 21 further comprising a grid layer arranged between a first mirror means and a second mirror means forming a resonator of the VCSEL device.

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36. The polarization-stable VCSEL device of claim 35, wherein said grid layer generates a reflectivity difference of about 0.5% to 15%.
37. The polarization-stable VCSEL device of claim 28, wherein a width of stripes of the grid layer is in the range of about 7 μm to about 0.1 μm .
38. The polarization-stable VCSEL device of claim 35, wherein a width of stripes of the grid layer is in the range of about 7 μm to about 0.1 μm .

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